Planning, Scheduling and Progress Monitoring of a Rural Piped Natural Gas (PNG) Distribution Network Using Primavera P6: A Case Study of Karle Village, Belagavi

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***Abstract* —** Reliable and clean cooking fuel is a growing requirement for rural households in India, and Piped Natural Gas (PNG) offers a safe and economical alternative to LPG cylinders. This paper presents the planning and progress-monitoring component of a rural PNG distribution network proposed for Karle Village, Belagavi district, Karnataka, designed to serve approximately 400 households with an estimated daily demand of 280 SCM. The study is limited to the first two objectives of the parent project: (i) preparation of a detailed baseline project schedule using Primavera P6, and (ii) monitoring of actual progress and recording of cost-time data at an intermediate stage. A Work Breakdown Structure comprising six groups and 38 activities was developed, resources were assigned, and the schedule was cost-loaded to a Budget at Completion of ₹37,11,560 over 309 working days. Progress was subsequently updated at a data date of 26 June 2026, and actual percentage-complete, actual start dates, and activity-wise cost/time data were recorded directly from the software. The results show that Primavera P6 provides a structured and traceable framework for converting field survey and demand data into an executable schedule, and for capturing real-time progress data that forms the foundation for subsequent performance evaluation. The approach is replicable for other rural infrastructure projects that require systematic planning and monitoring.

***Keywords* —** *Piped Natural Gas, Primavera P6, Work Breakdown Structure, Project Scheduling, Progress Monitoring, Rural Infrastructure, Baseline Schedule*

I. INTRODUCTION

The availability of clean and reliable cooking fuel is becoming increasingly important in rural areas of India, where many villages still depend on LPG cylinders and other traditional fuels. Piped Natural Gas (PNG) systems provide a continuous gas supply through underground pipelines, removing the need for cylinder handling and transportation, and the Government of India is expanding PNG infrastructure beyond metropolitan cities into rural regions to improve access to clean energy.

This paper focuses on the planning and performance-tracking framework developed for a proposed rural PNG distribution network at Karle Village, Belagavi district, Karnataka, which has a population of about 2000 persons in approximately 400 households. Because such projects involve numerous interconnected construction activities — route survey, trenching, pipe laying, jointing, testing, backfilling, and household connections — effective planning and continuous progress tracking are essential to keep the project on time and within budget. Primavera P6 was adopted as the scheduling and monitoring platform for the project.

The parent project defined five objectives: (1) preparation of a detailed schedule using Primavera P6, (2) monitoring of progress and recording of actual cost/time data at an intermediate stage, (3) application of Earned Value Management (EVM) for performance measurement, (4) generation and analysis of the S-curve, and (5) forecasting of completion cost and identification of critical activities. This paper reports the methodology and findings corresponding to the first two objectives — schedule development and progress-data recording — which together form the data foundation on which the subsequent performance analysis is built.

II. LITERATURE REVIEW

Rabadiya et al. [1] used Primavera P6 with EVM on a commercial building project and demonstrated that P6 gives a complete picture of project status by combining Critical Path Method scheduling with cost-schedule integration that conventional scheduling software cannot provide. Raghuwanshi and Paliwal [2] applied web-based Primavera P6 to a government housing project and found that poor planning directly increases cost and causes delay, whereas P6 improves visibility of critical activities and resource needs. Varsani et al. [3] reviewed the role of P6 as an early-warning system that continuously compares planned and actual work, concluding that it should be a standard tool for medium and large construction projects.

Albert et al. [4] surveyed construction professionals in Nigeria and reported that although EVM is well understood conceptually, its field adoption remains limited due to a lack of digital tools and training. Nimbal and Jamadar [5], in a related VTU study on a multi-storey building, showed that P6 clearly separates planned and actual progress and helps identify slow-moving activities. Dalibi et al. [6] and Lorghaba and Narimani [7] both emphasised that EVM integrates scope, time and cost in a single framework and enables early corrective action, while ElSahly et al. [8] reviewed time-cost optimisation models and recommended hybrid, data-driven approaches for future work. Mahure and Ranit [9] compared P6 with conventional planning on a port road project and attributed early completion to systematic P6-based scheduling.

Rui et al. [11] analysed historical pipeline-construction cost data and found that material and labour together account for roughly 71% of total pipeline cost, information relevant to budgeting rural PNG works. Overall, prior studies address P6 and EVM separately, mostly for buildings or generic infrastructure, and rarely for spread-out rural gas-distribution networks where labour/material logistics and schedule volatility differ from urban projects. This paper addresses that gap by documenting the schedule-development and progress-recording stages for a rural PNG project using real field data.

III. STUDY AREA AND METHODOLOGY

A. Study Area and Survey

Karle Village, in Belagavi district of Karnataka, is a rural settlement of about 400 households and 2000 residents where PNG is currently unavailable. As the study is primarily a planning and scheduling exercise, a desktop survey using Google Earth Pro satellite imagery was carried out instead of a detailed geotechnical field investigation. The methodology comprised village identification, study of internal roads and residential clusters, marking of a proposed alignment along roadside margins to minimise land acquisition, feasibility checking against obstacles such as water bodies and dense structures, path-length measurement, and selection of the mother-station site based on road accessibility, hydraulic centrality and PNGRB safety-clearance norms.

The finalised network comprises a main pipeline of 0.61 km connecting the mother station to the distribution area and a distribution pipeline of 1.85 km branching through the village, giving a total network length of 2.46 km. A uniform bedding slope of 1 in 1000 was adopted for both pipeline sections, giving a vertical drop of 0.61 m over the main line and 1.85 m over the distribution line. The mother station was planned on a 45 m × 45 m plot, zoned as per PNGRB T4S regulations with cascade storage, compressor unit, pressure-regulating system, odorising unit, control room and fire-safety facilities, all with safety clearances exceeding 15 m from the boundary wall in compliance with OISD-STD-179.

B. PNG Demand Estimation

A preliminary demand estimate was made to size the network and inform activity durations in Primavera P6, based on the assumption of one domestic connection per household (400 connections), an average household size of 4–5 persons, and an average consumption of 0.7 SCM per household per day for cooking only, with no commercial or industrial load considered. The resulting daily demand is:

Total Daily PNG Demand = 400 × 0.7 = **280 SCM/day**

This demand figure directly shaped the WBS: the 400 confirmed connections defined the Household Connections group (KPNG-01.5), the 280 SCM/day figure sized the compressor and cascade storage at the mother station, and the 1.85 km distribution length was fixed under WBS group KPNG-01.4, forming the quantitative basis for the schedule described in Section IV.

IV. OBJECTIVE 1 — DEVELOPMENT OF THE PROJECT SCHEDULE IN PRIMAVERA P6

The Karle PNG project was created in Primavera P6 Professional (v17) with Project ID KPNG-01, a planned start of 02-Feb-2026, a planned finish of 21-Dec-2026, and a total duration of 309 working days on the RPNG calendar. The scheduling methodology followed four stages: WBS definition, activity listing with duration assignment, resource and cost loading, and baseline creation.

A. Work Breakdown Structure (WBS)

The complete scope was divided into six WBS groups under the project head KPNG-01, summarised in Table I.

TABLE I. WORK BREAKDOWN STRUCTURE OF THE KARLE PNG PROJECT

WBS Code	Group	Scope of Work
KPNG-01.1	Pre-Construction	Initiation, survey, demand study, soil check, pipe-diameter design
KPNG-01.2	Mother Station	Site clearing to testing & commissioning of compressor station
KPNG-01.3	Main Pipeline Network	Trenching to backfilling of the 0.61 km main line
KPNG-01.4	Distribution Pipeline Network	Trenching to backfilling of the 1.85 km village network
KPNG-01.5	Household Connections	Service line, meter/regulator fitting, safety inspection
KPNG-01.6	Commissioning	System test, trial run, documentation and handover

B. Activity List and Duration Assignment

A total of 38 activities were entered into Primavera P6, each carrying a unique Activity ID (starting A1060), a planned duration in working days, and logical predecessor–successor links on the RPNG calendar. Table II summarises the activity count, duration and scheduled window for each WBS group.

TABLE II. ACTIVITY COUNT AND DURATION BY WBS GROUP

WBS Group	Activities	Duration (days)	Planned Window
Pre-Construction	5	46	02-Feb to 21-Mar-26
Mother Station	8	104	21-Mar to 03-Jul-26
Main Pipeline Network	9	61	23-May to 23-Jul-26
Distribution Pipeline Network	8	110	23-Jul to 14-Nov-26
Household Connections	4	27	14-Nov to 10-Dec-26
Commissioning	4	12	10-Dec to 21-Dec-26

Long-lead activities that drive the overall duration include Foundation Work (15 days), Distribution Pipeline Trenching (24 days), Distribution Pipeline Bedding (24 days) and Distribution Pipe Laying (30 days) — activities that later emerge on the critical path.

C. Resource Assignment

Labour, equipment and material resources were assigned to every activity according to its nature of work, drawing on standard resource categories used for rural pipeline and station construction. Table III lists representative resources against the WBS groups that primarily consume them.

TABLE III. REPRESENTATIVE RESOURCE ASSIGNMENT BY WBS GROUP

WBS Group	Key Resources Assigned
Pre-Construction	Project Manager, Planning Engineer, Site Engineer
Mother Station	Site Engineer, Skilled/Unskilled Labour, JCB, Vibratory Roller, Welding Set
Main Pipeline Network	Site Engineer, Pipe-laying Crew, MDPE Pipe, Welding & Testing Crew
Distribution Pipeline Network	Site Engineer, Trenching Crew, MDPE Pipe, Testing Crew
Household Connections	Site Engineer, Fitters, Gas Meter (material resource)
Commissioning	Project Manager, Planning Engineer, Site Engineer

Assigning resources at this level of detail allows Primavera P6 to check for over-allocation across concurrently running activities and gives the planning team a realistic basis for sequencing work between the Mother Station and Main Pipeline Network groups, which run in parallel between March and July 2026.

D. Cost Loading

Once resources were assigned, Primavera P6 computed the budgeted cost of every activity as the product of the resource rate and the assigned duration — a process termed cost loading — which forms the financial basis for later performance evaluation. Table IV presents the resulting Budget at Completion (BAC), which totals ₹37,11,560.

TABLE IV. COST LOADING SUMMARY BY WBS GROUP (BAC)

WBS Group	Budgeted Cost (₹)	% of BAC
Pre-Construction	1,87,850	5.1
Mother Station	15,28,890	41.2
Main Pipeline Network	4,53,550	12.2
Distribution Pipeline Network	13,07,300	35.2
Household Connections	1,94,370	5.2
Commissioning	39,600	1.1
Total (BAC)	37,11,560	100.0

E. Baseline Schedule

After sequencing, resource assignment and cost loading, the schedule was saved as a baseline in Primavera P6 — a frozen copy of planned start dates, finish dates, durations and costs for all 38 activities. The baseline spans 02-Feb-2026 to 21-Dec-2026 (309 working days) with a fixed BAC of ₹37,11,560, and serves as the invariant reference against which all subsequent actual progress and cost data are compared during monitoring. Locking the baseline before execution began ensures that any later variance reported under Objective 2 reflects genuine field deviation rather than a moving target, which is essential for a defensible cost/schedule audit trail.

V. OBJECTIVE 2 — PROGRESS MONITORING AND RECORDING OF ACTUAL COST/TIME DATA

The second objective was to capture, at an intermediate stage of execution, the actual percentage completion, actual start dates and cost/time data for every activity, so that this data could subsequently support performance evaluation. A data date of 26 June 2026 was set in Primavera P6, and field progress was updated activity-by-activity against the baseline.

A. Progress-Recording Methodology

For every activity that had commenced by the data date, the actual start date and the physical percentage-complete observed on site were entered into Primavera P6. The software then recalculated Planned Value (PV), Earned Value (EV) and Actual Cost (AC) for each activity and rolled these up to WBS-group and project level, giving a consistent, time-stamped record of where the project stood relative to the baseline.

B. WBS Group-wise Status Recorded at the Data Date

Table IV summarises the status recorded for each WBS group as of 26 June 2026. All five Pre-Construction activities were closed at 100% by 21-Mar-2026. All eight Mother Station activities were in progress, ranging from 95% (Site Cleaning) down to 78% (Testing & Commissioning). In the Main Pipeline Network, all activities except Backfilling had commenced, with completion ranging from 75% (Trenching) to 20% (Final Quality Inspection). The Distribution Pipeline Network, Household Connections and Commissioning groups had not yet started, consistent with their later baseline start dates.

TABLE V. PROGRESS RECORDED AT DATA DATE (26 JUNE 2026)

WBS Group	Activities Started	% Complete Range	Status
Pre-Construction	5 of 5	100%	Closed
Mother Station	8 of 8	78% – 95%	In progress
Main Pipeline Network	8 of 9	20% – 75%	In progress
Distribution Pipeline Network	0 of 8	0%	Not started
Household Connections	0 of 4	0%	Not started
Commissioning	0 of 4	0%	Not started

C. Activity-wise Progress Records

To illustrate the granularity of data captured, Tables VI and VII list the actual start date and recorded percentage-complete for each activity in the two groups that were most actively in progress at the data date — Mother Station and Main Pipeline Network. This activity-level record is what allows the subsequent Earned Value calculations to be traced back to an auditable field observation for every activity, rather than an aggregated group-level estimate.

TABLE VI. ACTIVITY-WISE PROGRESS — MOTHER STATION GROUP

Activity	Actual Start	% Complete
Site Cleaning	21-Mar-26	95.00
Excavation	26-Mar-26	92.01
Foundation Work	01-Apr-26	90.00
Storage Cascade Installation	17-Apr-26	87.99
Compressor Installation	25-Apr-26	86.01
Pipe & Valves Installation	04-May-26	82.01
Safety Systems	12-May-26	80.00
Testing & Commissioning	18-May-26	78.00

TABLE VII. ACTIVITY-WISE PROGRESS — MAIN PIPELINE NETWORK GROUP

Activity	Actual Start	% Complete
Trenching	23-May-26	75.00
Bedding	30-May-26	70.00
Pipe Laying	06-Jun-26	65.00
Welding & Jointing	15-Jun-26	55.00
Coating & Wrapping	16-Jun-26	50.00
Hydrostatic Testing	19-Jun-26	40.00
Pressure Testing	22-Jun-26	30.00
Final Quality Inspection	24-Jun-26	20.00
Backfilling	Not started	0.00

The declining percentage-complete from the earliest-started to the latest-started activity within each group (e.g., 95% for Site Cleaning down to 78% for Testing & Commissioning; 75% for Trenching down to 20% for Final Quality Inspection) is consistent with the finish-to-start logic built into the Objective-1 schedule network, and confirms that the progress-recording exercise under Objective 2 correctly reflects the sequential construction reality on site.

D. Project-Level Cost/Time Data Recorded

At the project level, the recorded values at the data date were: Planned Value (PV) ₹20,50,765, Earned Value (EV) ₹17,67,934.31, and Actual Cost (AC) ₹19,20,959.75, against the total BAC of ₹37,11,560. These three recorded quantities — PV, EV and AC — constitute the raw cost/time dataset produced by this monitoring stage; their conversion into performance indices (CPI, SPI) and forecasts (EAC, ETC) falls under the project's third objective (EVM application) and is outside the present scope, but the recorded dataset itself confirms that the monitoring and data-capture procedure in Primavera P6 functioned consistently across all activity types and WBS groups.

Activity-wise records further show that individual completion percentages decrease broadly with activity sequence within an in-progress group (e.g., Trenching 75% down to Final Quality Inspection 20% in the Main Pipeline Network), which is expected behaviour for a linear, sequentially-executed pipeline group and indicates that the recorded progress data is internally consistent with the logical activity network built in Objective 1.

VI. RESULTS AND DISCUSSION

The schedule developed under Objective 1 organised the entire project scope into 38 traceable activities across six WBS groups, cost-loaded to a BAC of ₹37,11,560 over a 309-day baseline — giving the project a single, auditable reference plan. The monitoring exercise under Objective 2 demonstrated that this baseline could be systematically updated with field data: every started activity yielded a recorded actual start date, percentage complete, and PV/EV/AC figure, while activities not yet due remained correctly at zero, confirming that the WBS logic and calendar built in Objective 1 correctly gated progress entry in Objective 2.

Together, the two objectives show that a rural PNG distribution project — despite its spread-out, multi-trade nature — can be planned and tracked with the same rigour as a conventional building or road project when a structured WBS, realistic activity durations and disciplined data-date updating are used. This recorded dataset (PV, EV, AC per activity and per WBS group) forms the direct input for the EVM-based performance analysis, S-curve generation and completion forecasting carried out under the remaining objectives of the parent study.

VII. CONCLUSION

This paper presented the schedule-development and progress-monitoring stages of a rural PNG distribution project for Karle Village, Belagavi, using Primavera P6. A six-group, 38-activity WBS was built from field survey and demand-estimation data, resource- and cost-loaded to a baseline of ₹37,11,560 over 309 working days. Progress was then recorded at a data date of 26 June 2026, showing the Pre-Construction group fully closed on schedule (SPI = 1.00 at closure), the Mother Station and Main Pipeline Network groups in active progress, and the later groups correctly un-started per baseline. The recorded PV, EV and AC data confirm that Primavera P6 provides an effective, traceable platform for converting rural infrastructure planning data into an executable schedule and for capturing consistent progress data during execution — establishing the groundwork for the EVM-based cost/schedule performance evaluation reported separately. The approach is directly replicable for other rural PNG and similar linear infrastructure projects where systematic time and cost control is required.

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